

CLAIMS

What Is Claimed Is:

5 1. An improved method for partially or completely removing organic coatings, films, layers or residues from a substrate, said method comprising:

(1) subjecting said substrate with said organic material thereon to a vapor consisting essentially of water-free gaseous sulfur trioxide for a period of time to at least partially react said organic material with said sulfur trioxide, said substrates being maintained at a temperature in said
10 range from about room temperature to 400°C; and

(2) subjecting said substrate to a solvent rinse to at least partially remove said reacted organic material;

wherein said improvement comprises said following steps:

15 (a) providing said substrate with said organic material thereon;

(b) subjecting said substrate of step (a) to a precursor chemical or physical treatment prior to step (1) capable of facilitating said reaction of said sulfur trioxide with said organic material to be removed;

20 (c) carrying out said step (1) so that said water-free, gaseous sulfur trioxide reacts with said organic material to form reacted and unreacted organic matter;

(d) optionally, subjecting said organic coatings, films, layers or residues to a pre-rinse chemical or physical treatment;

25 (e) carrying out said step (2) to remove said reacted and unreacted organic matter from said substrate; and

(f) subjecting said substrate to a chemical or physical post-rinse treatment subsequent to step (2) capable of removing any residual organic matter from said substrates remaining after said solvent rinse.

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2. The method of Claim 1 wherein said substrate consists of at least one portion of a device selected from the group consisting of semiconductor devices and wafers, liquid crystal display devices, flat-panel displays, printed circuit boards, magnetic read/write heads, and thin-film read/write heads.

3. The method of Claim 2 wherein said substrate is selected from the group consisting of Group IV elements, III-V compound semiconductors, oxides, nitrides, oxynitrides, organic films, organic dielectrics, organo-metallic complexes and polymers, metals, and metal alloys.

4. The method of Claim 3 wherein said Group IV elements are selected from the group consisting of silicon, polysilicon, and germanium, said III-V compound semiconductors consist essentially of gallium arsenide, said oxides are selected from the group consisting of crystalline and glassy oxides, and said organic dielectrics consist essentially of an organic polymer.

5. The method of Claim 4, wherein said organic polymer is selected from the group consisting of polyimides, copolyimides, polyamides, polyamide-imides, fluorinated polyimides, poly(arylenethers), fluorinated poly(arylenethers), perfluorinated alkylene oxides, parylene (N, C, D, or F type), poly(phenylquin-oxalines), poly-naphthalene, poly-fluorinated naphthalene, benzocyclobutene (BCB), amorphous fluoropolymers, such as polytetrafluoroethylene, perfluorocyclobutane aromatic ether (PFCB), and fluorinated carbon.

6. The method of Claim 1 further including:

in step (b) subjecting said organic material to said precursor chemical or precursor physical treatment, including, prior to said subjecting

(a1) placing said substrate in a chamber, and

(a2) purging said chamber with a dry inert gas;

in step (1) introducing said vapor consisting essentially of water-free gaseous sulfur trioxide into said chamber or in a separate chamber to react with said organic material, including allowing said period of time to pass to permit reaction between said sulfur trioxide and said organic material; and

in step (c) ending said reaction between said sulfur trioxide and said organic material by subjecting said substrate to an end-point chemical or end-point physical treatment.

7. The method of Claim 6 wherein said dry, inert gas consists essentially of nitrogen or argon.

8. The method of Claim 1 wherein said precursor chemical treatment is
5 selected from the group consisting of exposure to chemically active process gases, chemically inert process gases, and solvents, present in an amount to facilitate said reaction of said sulfur trioxide with said organic coatings, films, layers or residues.

10 9. The method of Claim 8 wherein said chemically active process gases are selected from the group consisting of oxygen, nitrous oxide, steam, and vapor phase hydrogen peroxide and wherein said chemically inert process gases are selected from the group consisting of nitrogen and argon.

15 10. The method of Claim 9 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

20 11. The method of Claim 1 wherein said precursor physical treatment is selected from the group consisting of exposure to heat, ultra-violet radiation, laser energy, kinetic energy, high-pressure deionized water sprays, physical scrubbing, ultrasonic and megasonic sound energy.

25 12. The method of Claim 1 wherein said precursor chemical or physical treatment is carried out at a temperature between room temperature and 400°C.

30 13. The method of Claim 1 wherein said solvent rinse is performed in a solvent selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

14. The method of Claim 1 wherein said solvent rinse is simultaneously carried out in the presence of megasonic or ultrasonic energy, heat, ultra-violet radiation, or laser energy.

15. The method of Claim 1 wherein said post-rinse chemical treatment is selected from the group consisting of further exposure to chemically active process gases or vapors, chemically inert process gases, and solvents, present in an amount to facilitate said removal of any residual organic material from said substrates remaining after said solvent rinse.

16. The method of Claim 15 wherein said chemically active process gases are selected from the group consisting of oxygen, nitrous oxide, steam, and vapor phase hydrogen peroxide and wherein said chemically inert process gases are selected from the group consisting of nitrogen and argon.

17. The method of Claim 15 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

18. The method of Claim 1 wherein said post-rinse physical treatment is selected from the group consisting of further exposure to heat, ultra-violet radiation, laser energy, kinetic energy, high-pressure deionized water sprays, physical scrubbing, CO₂ snow processing, ultrasonic and megasonic sound energy.

19. The method of Claim 1 wherein said post-rinse chemical or physical treatment is carried out at a temperature between room temperature and 400°C.

20. The method of Claim 1 wherein step (c) further comprises subjecting said organic materials to simultaneous exposure to a component selected from the group consisting of other chemically active process gases and vapors, chemically inert process gases, vaporized solvents, heat, ultra-violet radiation, and laser energy.

21. The method of Claim 20 wherein said chemically active process gases are selected from the group consisting of oxygen, nitrous oxide, steam,

and vapor phase hydrogen peroxide and wherein said chemically inert process gases are selected from the group consisting of nitrogen and argon.

22. The method of Claim 20 wherein said solvents are selected from
5 the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

23. The method of Claim 1 wherein each said subjecting step is independently performed for a period of time up to about 5 minutes.

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24. The method of Claim 1 wherein said organic materials are selected from the group consisting of polymerized photoresists, paints, resins, single and multilayer organic polymers, organo-metallic complexes, positive optical photoresist, negative optical photoresist, electron-beam photoresists, X-ray
15 photoresists, ion-beam photoresists, ion-implanted photoresists, and other hardened photoresists, wherein said organic polymers are selected from the group consisting of polyimides, copolyimides, polyamides, polyamide-imides, fluorinated polyimides, poly(arylenethers), fluorinated poly(arylenethers), perfluorinated alkylene oxides, parylene (N, C, D, or F type), poly(phenylquinoxalines), poly-naphthalene, poly-fluorinated naphthalene, benzocyclobutene
20 (BCB), amorphous fluoropolymers, such as polytetrafluoroethylene, perfluorocyclobutane aromatic ether (PFCB), and fluorinated carbon.

25. The method of Claim 1 further comprising: subjecting said organic
25 coatings, films, layers or residues to said pre-rinse chemical or physical treatment.

26. The method of Claim 25 wherein said pre-rinse chemical treatment is selected from the group consisting of further exposure to chemically active
30 process gases or vapors, chemically inert process gases, and solvents.

27. The method of Claim 26 wherein said chemically active process gases are selected from the group consisting of oxygen, nitrous oxide, steam,

and vapor phase hydrogen peroxide and wherein said chemically inert process gases are selected from the group consisting of nitrogen and argon.

28. The method of Claim 26 wherein said solvents are selected from
5 the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

29. The method of Claim 25 wherein said pre-rinse physical treatment
consists of further exposure to a component selected from the group consist-
10 ing of heat, ultra-violet radiation, laser energy, kinetic energy, high-pressure deionized water sprays, physical scrubbing, CO₂ snow processing, ultrasonic and megasonic sound energy.

30. The method of Claim 25 wherein said pre-rinse chemical or physi-
15 cal treatment is carried out at a temperature between room temperature and 400°C.